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Human Factors Engineering #2 Crewstation Assessment for the OH-58F Helicopter

by David B. Durbin, Jamison S. Hicks, Michael Sage Jessee, Brad M. Davis, and Mary Carolyn King

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Aberdeen Proving Ground, MD 21005

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Human Research and Engineering Directorate, ARL

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14. ABSTRACT
An assessment was conducted to identify design characteristics of the OH-58F crewstation that enhanced or degraded pilot performance. The following were assessed in an OH-58F simulator: Aircrew workload, aircrew situation awareness, the crewstation interface, visual gaze and dwell times (using a head and eye tracker), the audio alerting system, and the potential for pilot simulator sickness. Pilots flew missions based on a battlefield environment simulating southwest Asia. Each successive mission increased in difficulty in order to impose progressively greater workload on the pilots.
Pilots reported that the workload was manageable for the tasks they performed during the missions. The overall workload ratings provided by the pilots and subject matter experts (SMEs) were lower than the Objective and Threshold workload rating requirements listed in the OH-58F Capability Development Document. The pilots reported that they had moderate levels of situation awareness during the missions. They commented that the crewstation design aided them in conducting navigation, communication, and reconnaissance tasks. The pilots recommended minor design changes be made to the crewstation to enhance usability. The assessment is part of the continuous evaluation process to develop and refine the crewstation design. This process includes human factors modeling, simulation, developmental and operational testing.

15. SUBJECT TERMS
pilot workload, situation awareness, crewstation assessment, pilot-crewstation interface, Army Aviation

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1. Introduction

1.1 Purpose and Overview

The U.S. Army Research Laboratory (ARL), Human Research and Engineering Directorate (HRED) conducted the second in a series of human factors evaluations of the OH-58F Kiowa Warrior Cockpit and Sensor Upgrade Program (KW CASUP) crewstation during 11–15 July 2011 at the Systems Simulation and Development Directorate (SSDD) Apex Laboratory, Redstone Arsenal, AL. The evaluation was conducted to identify design characteristics of the crewstation that enhanced or degraded pilot performance. Aircrew workload, aircrew situation awareness, the crewstation interface, pilot visual workload, audio alerting system, and the potential for pilot simulator sickness were assessed. The OH-58F crewstation simulator (figures 1 and 2) was used to conduct the evaluation. The human factors evaluation is part of the continuous assessment process to develop and refine the crewstation design. The continuous assessment process includes modeling, simulation, developmental and operational testing.
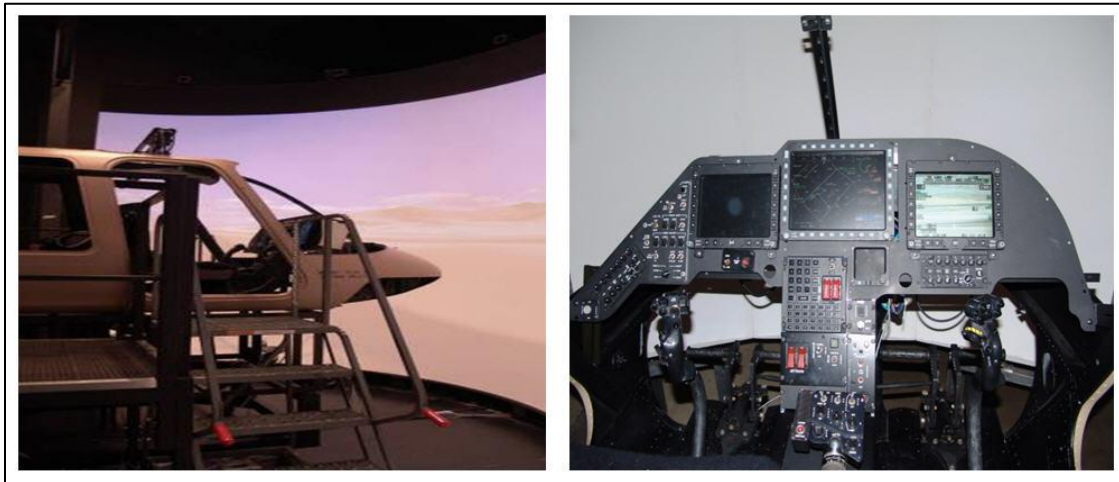

Figure 1. OH-58F crewstation simulator.
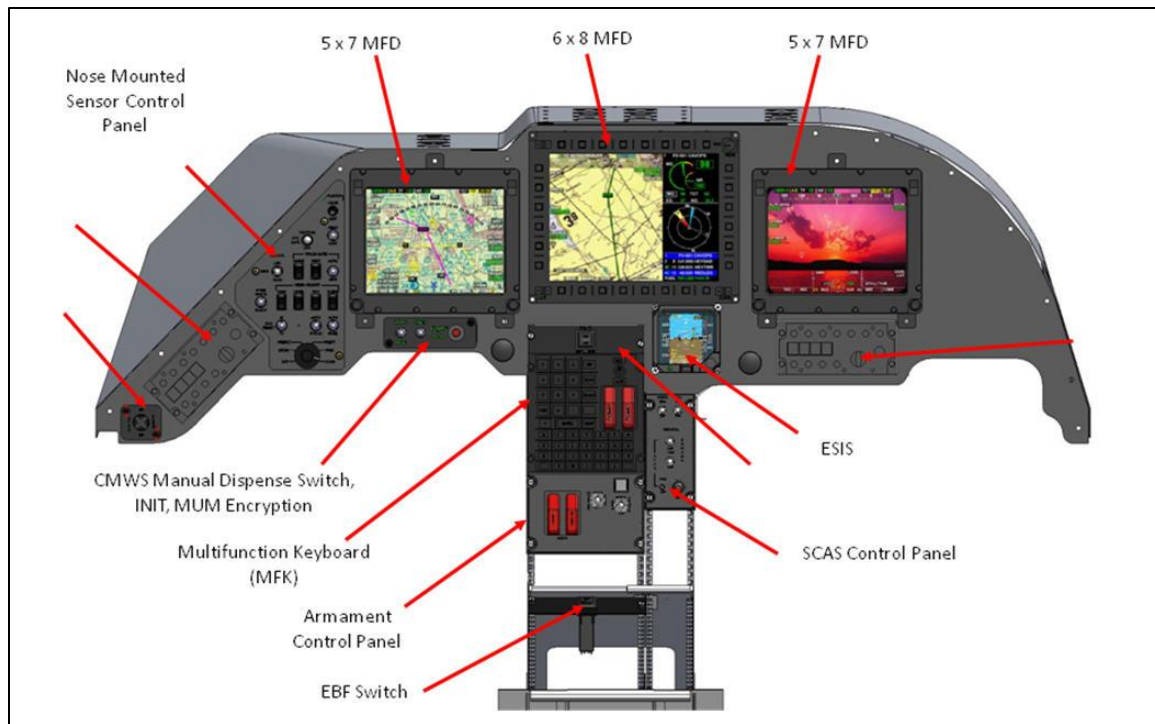
Figure 2. OH-58F instrument panel.

Pilots received 1.5 days of training prior to the beginning of the evaluation. The training was conducted at SSDD and consisted of classroom instruction and hands-on flight training using a desktop simulator and the OH-58F crewstation simulator.

The pilots flew the same missions during training that they later flew during the record trials. The mission scenario was based on a battlefield environment simulating southwest Asia. Each successive mission increased in difficulty in order to impose progressively greater workload on the pilots. The aircrews performed route, area, and landing zone/pick-up zone reconnaissance, call-for-fire, and specific Aircrew Training Manual (ATM) tasks during each mission. Each ATM task has prescribed conditions and standards to which both crewmembers had to perform to ensure mission accomplishment. The pilots rotated seat positions during the evaluation.

During the formal evaluation, two sets of aircrews conducted three reconnaissance missions and one aircrew performed two reconnaissance missions (for a total of eight missions). The missions consisted of flight segments in visual meteorological conditions (VMC), instrument meteorological conditions (IMC), and tactical conditions. The mission scenarios were developed by the Training and Doctrine Command (TRADOC) Capability Manager, Reconnaissance Attack (TCM RA) office, Fort Rucker, AL. The scenarios were developed in accordance with scout aircraft tactics, techniques, and procedures (TTP).

Prior to each mission, the pilots received a briefing; at the conclusion of each mission, the aircrew completed human factors surveys. Before and after each mission, they completed the

Simulator Sickness Questionnaire (SSQ); after each mission, they completed the Bedford Workload Rating Scale (BWRS), China Lake Situational Awareness (CLSA) rating scale, and audio alerting survey. The pilots completed the Pilot-Crewstation Interface (PCI) questionnaire after they completed all of their missions. During each mission, pilots wore an eye tracker that we used to assess their visual workload. In addition to the pilot data, subject matter experts (SMEs) provided an independent assessment of aircrew workload, situation awareness, and mission success. After each mission, the SMEs completed an aircrew workload, situation awareness and mission success survey. After the aircrews completed the mission and surveys, they participated in a mission debriefing and after action review (AAR).

1.2   Assessment of Crew Workload

A common definition of pilot workload is "the integrated mental and physical effort required to satisfy the perceived demands of a specified flight task" (Roscoe, 1985). It is important to assess pilot workload because mission accomplishment is related to the mental and physical ability of the crew to effectively perform their flight and mission tasks. If one or both pilots experience excessively high workload while performing flight and mission tasks, the tasks may be performed ineffectively or abandoned. In order to assess whether the pilots are task-overloaded during the mission profiles, the level of workload for each pilot must be evaluated.

1.3   Bedford Workload Rating Scale

The pilots completed the BWRS (appendix A) immediately after each mission to rate the level of workload that they experienced when performing ATM tasks during missions. Personnel from the TCM RA, ARL HRED, SSDD, and the Armed Scout Helicopter Program Managers Office selected the ATM tasks (appendix A) because they were estimated to have the most impact on pilot workload during the missions.

The military, civil, and commercial aviation communities for pilot workload estimation (Roscoe & Ellis, 1990) have used the BWRS extensively. It requires pilots to rate the level of workload associated with a task based on the amount of spare capacity they feel they have to perform additional tasks. Spare workload capacity is an important commodity for scout pilots because they are often required to perform several tasks concurrently. For example, pilots often perform navigation tasks, communicate via multiple radios, monitor aircraft systems, and assist the pilot on the controls with flight tasks (e.g., maintain airspace surveillance) within the same time interval. Mission performance is reduced if pilots are task-saturated and have little or no spare capacity to perform other tasks. Integration of the OH-58F crewstation should help ensure that pilots can maintain adequate spare workload capacity while performing flight and mission tasks. The OH-58F has a Capability Development Document (CDD) requirement that aircrew workload not exceed 6.0 (Threshold) and 5.0 (Objective) on the Bedford Scale.

1.4　Visual Workload

An eye tracker was used during the evaluation to assess visual gaze and dwell times for the pilots. The data were collected to help determine how well the design of the crewstation allowed the flying pilot to remain focused outside the aircraft during visual flight rules (VFR) flight and how well the non-flying pilot was able to maintain visual focus outside the aircraft to assist with navigation (e.g., identification of terrain features), local security, terrain flight, etc. Visual gaze and dwell time data help identify if pilots experience excessive visual workload or cognitive capture because they had problems interpreting information presented to them on the crewstation displays.

1.5　Assessment of Crew Situation Awareness

Situational awareness (SA) can be defined as the pilot's mental model of the current state of the flight and mission environment. A more formal definition is "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley, 1988). SA was important to assess because it had a direct impact on pilot and system performance. Good SA should increase the probability of good decision-making and performance by aircrews when conducting flight and mission tasks in the OH-58F.

1.6　CLSA

The CLSA (appendix B) is a unidimensional rating scale for pilots to report their perceived SA. The CLSA uses a five point scale that requires pilots to rate their knowledge of aircraft energy state, tactical environment and mission, ability to anticipate and accommodate trends, and if they shed tasks during the mission.

1.7　Assessment of the PCI

The PCI directly affects crew workload and SA during a mission. A crewstation designed to augment the cognitive and physical abilities of crews will minimize workload, enhance SA, and contribute to successful mission performance. The pilots completed a PCI questionnaire (appendix C) to identify any problems with the usability of the controls, displays, or subsystems.

1.8　Assessment of Simulator Sickness

Simulator sickness has been defined as a condition where pilots suffer physiological discomfort in the simulator, but not while flying the actual aircraft (Kennedy et al., 1989). Generally, simulator sickness is believed to be caused by a mismatch either between the visual and vestibular sources of information about self-motion, or between the sensory information (e.g., acceleration cues) presented by the simulator and the sensory information presented by the primary aircraft that the pilot operates. When the sensory information presented by the simulator does not match the aircraft, the pilot's nervous system reacts adversely to the sensory mismatch

and the pilot begins to experience discomfort. Characteristics of simulator sickness include nausea, dizziness, drowsiness, and several other symptoms (Kennedy et al., 1989) and can be distracting to pilots; therefore, assessment of simulator sickness is important. Pilot distraction is one of the operational consequences of simulator sickness listed by Crowley (1987). If pilots are distracted by the discomfort that they feel during missions, their performance is likely to suffer. Additionally, the discomfort could influence the perceived levels of workload and SA that the pilots experienced during a mission.

1.9 SSQ

The SSQ was administered to the pilots to estimate the severity of physiological discomfort that they experienced during missions and help assess whether they were being distracted by the discomfort. The SSQ (Kennedy et al., 1993) is a checklist of 16 symptoms that are categorized into three subscales. The subscales are oculomotor (e.g., eyestrain, difficulty focusing, blurred vision), disorientation (e.g., dizziness, vertigo), and nausea (e.g., nausea, increased salivation, burping) are combined to produce a Total Severity score. The Total Severity score is an indicator of the overall discomfort that the pilots experienced during the mission.

1.10 Assessment of Audio Alerting System

An audio alerting system should immediately alert and clearly inform the aircrew about a problem with their aircraft that requires attention (e.g., loss of an engine). Personnel from Psycho-Linguistic Research Associates (PLRA) conducted an assessment of the OH-58F audio alerting system. The purpose was to assess the following characteristics of the alerting system:

- Presentation logic

- Composition of the alerts

- Use of speech and sounds for the various alerts

- Utility of the audio alerting system functions and characteristics

- Workload associated with using the system

- Pilots' ratings of distinctiveness and speech intelligibility for two different text-to-speech voices

- Pilots' ratings of distinctiveness and recognizability for the alerting system sounds

1.11 SMEs

Two SMEs typically observed the missions and rated crew workload, crew SA, and mission success. The SMEs provided an independent assessment of the workload and SA levels experienced by the crews and helped determine if problems with crew workload or crew SA contributed to lack of mission success.

The SMEs were TCM RA personnel who had substantial experience conducting armed reconnaissance and attack missions and were familiar with the OH-58F crewstation. They observed each mission from the Battlemaster station where they could observe crewstation displays and the out-the-window view provided to the crew. They also listened to all audio communications between crewmembers and outside sources during the missions.

1.12 Simulation Environment

SSDD provides modeling and simulation support of weapon systems early in the acquisition process. This is accomplished through several methods, including man-in-the-loop simulators, distributed simulation experimentation, and constructive simulation development in the SSDD Apex Laboratory.

The Advanced Prototype Engineering and Experimentation (APEX) Lab is High-Level Architecture (HLA) and Distributed Interactive Simulation (DIS) compliant, and has the capability to connect to the Army's Battle Labs and other distributed simulation facilities through the Defense Research and Engineering Network (DREN).

The APEX Lab includes a Battlemaster control center that has access to each simulation playing on the network by means of a One Semi-Automated Forces (OneSAF) test bed terminal, data collection devices, headset communications, and video monitoring. All exercises are controlled from the Battlemaster station to ensure that all players are engaged in the exercise and all data collection devices are active. Time coordination and time stamping of video collection devices is achieved through an integrated Global Positioning System (GPS) clock. Audio and video are captured and routed throughout the lab and various conference rooms through a custom video capture and switching system.

The APEX Lab has a complete synthetic environment development team that is able to develop custom, correlated terrain databases that are designed to specifically enhance realism of the immersive environment and support operational scenarios for each event. The Battlefield Highly Immersive Visual Environment (BHIVE) provides this immersiveness with high-fidelity out-the-window (OTW) terrain databases and image generators. The BHIVE was developed in support of weapon system evaluation in an HLA/DIS compliant, man-in-the-loop, virtual environment. It was designed with a roll-in/roll-out capability to allow integration of several types of devices into the environment through a standard interface. This provides the flexibility to immerse multiple types of cockpits in a realistic and reusable synthetic world. Six projectors are used to project the OTW view onto an $180^{o} \times 60^{o}$ directional curved dome. The projection system is capable of edge blending for high-definition synthetic environments.

2. Method

2.1 Participants

Participants were five pilots from Fort Rucker, AL, and one pilot from the Tennessee Army National Guard. The pilots were warrant officers and rated in the OH-58D. One pilot held the rank of CW2, four pilots held the rank of CW3, and one pilot held the rank of CW4. Two pilots were assigned to the TCM RA, one pilot was assigned to the 110th Aviation Brigade, one pilot was assigned to the Directorate of Evaluation and Standardization, one pilot was assigned to the Directorate of Training and Doctrine, and one pilot was assigned to the 1-230 Air Cavalry Squadron, Tennessee. The pilots represented a fairly broad range of experience with their total flight hours ranging from 800–5300 hours. The relevant demographic characteristics of the pilots are listed in table 1.

Table 1. Pilot demographics (N = 6).

Summary of demographic Characteristics	Age (yrs)	Flight hours in OH-58D	Total flight hours in Army aircraft
Mean	37.5	2510	2868
Median	37.0	2525	2750
Range	35–42	600–4200	800–5300

2.2 Data Collection

The pilot questionnaires were developed in accordance with published guidelines for proper format and content (O'Brien and Charlton, 1996). A pretest was conducted to refine the questionnaires and to ensure that they could be easily understood and completed by pilots and SMEs.

The pilots completed the workload, audio alerting, and SA questionnaires after each mission. They completed the SSQ before and after each mission. The pilots completed the PCI questionnaire after they completed all of their missions. The SMEs completed questionnaires after each mission. Additional data were obtained from the pilots and the SME members during post-mission discussions and the final AAR. Questionnaire results were clarified with information obtained during post-mission discussions and the daily AARs.

2.3 Eye Tracker System

Pilot visual gaze and dwell times were collected with an eye tracking system (Model 501) from Applied Science Laboratories (ASL) and a head tracking system (Polaris Spectra) from Northern Digital Incorporated (NDI). These systems were used because they allowed unrestricted head movement during data collection and were compatible with the HGU-56 flight helmet worn by the pilots. This technology allowed the collection of digital data that specified point of gaze with

respect to stationary objects within the crewstation. The ASL software allowed data collectors to continuously monitor the eye position of the pilots by crosshairs superimposed over live imagery (figure 3). The software also included a built-in analysis tool that allowed data to be viewed in tabular or graphical format.
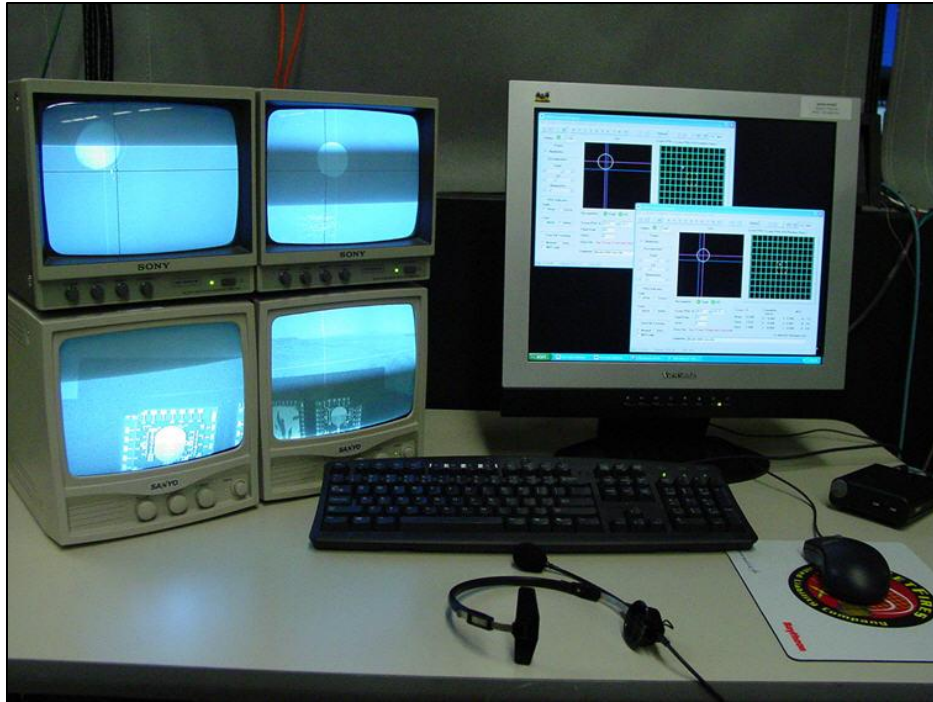
Figure 3. Eye tracker scene camera monitors and control panel interface.

2.4 Data Analysis

Pilot responses to the BWRS, CLSA, SSQ, audio alerting, and PCI questionnaires were analyzed with means and percentages. The eye tracker data were summarized by calculating the total percentage of fixations that occurred for the different areas of interest (AOI). Eight AOIs were created for the pilot and copilot:

- 5×7 multifunction display (MFD)

- 6×8 MFD

- Kneeboard

- OTW

- Outer left instrument panel (copilot)

- LPCAP (pilot)

- Lower console

A final category, called "Other," captured eye fixations not focused on a specific AOI. Results of the eye tracker data are contained in figures 5 and 6.

2.5   Evaluation Limitations

Limitations included the small sample size of pilots (N=6) who participated in the crewstation simulation assessment, limited amount of training provided to the pilots, and hardware/software limitations. The primary hardware and software limitations follow:

- Built-In Test (BIT) functions were not available

- Hands-On Grip (HOG) was functional for Joint Variable Message Format (JVMF) free text only

- Video Tape Recorder (VTR) was nonfunctional

- Health Usage Monitoring System (HUMS) was not available

- Circuit Breaker Panels were nonfunctional

- Nose Mounted Sensor (NMS) Linear Motion Control did not function if the NMS was pointed off the ground

- Video rocker switches were nonfunctional

- Hellfire was functional in lock-on-before-launch (LOBL) mode only

- Pulse Interval Module (PIM) codes were not available

- Certain display font sizes were slightly inaccurate

- Satellite Demand Assigned Multiple Access (DAMA) and frequency hop were nonfunctional

- Display map did not have Controlled Image Base (CIB) and 12.5 software functionality

These limitations are fairly common when simulating a complex aviation system. However, the information and data listed in the Results and Summary sections of this report should be interpreted based on these limitations. Additional data should be collected during future simulations and tests to augment and expand the findings contained in this report.

3. Results

3.1 Crew Workload

3.1.1 Mean Workload Ratings for Flight and Mission Tasks

The average mission workload rating was 2.75 for the pilot and 3.38 for the copilot (figure 4). These ratings indicate that the pilots and copilots typically felt that workload was tolerable for the flight and mission tasks they performed during the missions. Additionally, the ratings indicate that the pilots and copilots typically felt they had enough spare workload capacity to perform all desirable additional tasks (within the same time interval) during missions.
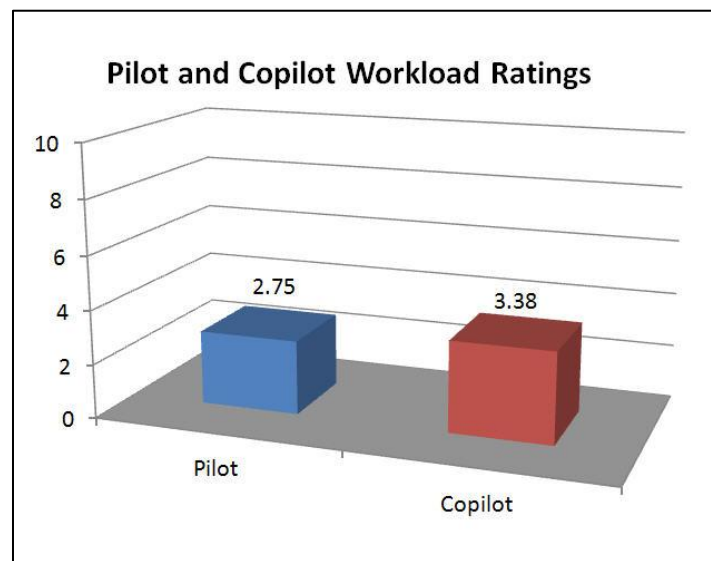
Figure 4. Pilot and copilot workload ratings.

The average workload ratings for flight and mission tasks (appendix A) provided by the pilots and copilots were lower than the Objective (5.0) and Threshold (6.0) BWRS workload rating requirements contained in the OH-58F CDD except for the following tasks:

- Perform Emergency GPS Recovery Procedure

- Perform an Autorotation

- Perform Unusual Attitude Recovery

- Respond to IMC Conditions

- Call for Tactical Air Strike

The pilots commented that the higher workload they experienced during these tasks was due to the intensive nature of the tasks and different flight handling characteristics of the simulator (simulator flight model) versus the actual aircraft.

3.1.1　SME Workload Ratings

SMEs provided an overall Bedford workload rating for each pilot during each mission that they observed. The average SME Bedford workload rating (table 2) was 3.31 for the pilot and 3.46 for the copilot for all missions, which indicates the SMEs believed that workload was tolerable for the pilots and copilots. Additionally, the ratings indicate that the SMEs felt that the pilots and copilots typically had sufficient spare workload capacity for attention to additional tasks. SME workload comments are listed in appendix A.

Table 2. SME Bedford workload ratings.

	Pilot	**Copilot**	**Overall (L+R seat)**
Average Workload	3.31	3.46	3.39
Standard Deviation	0.75	0.78	—

3.1.2　Visual Workload

Figure 5 shows the percentage of time that the pilots were visually focused (during VFR flight) on each AOI during the missions. It is interesting to note that the copilots typically spent only 14% of the time visually focused OTW during missions. The copilot needs to periodically maintain visual focus outside the aircraft to assist with navigation (e.g., identification of terrain and cultural features) and airspace surveillance. While the percentage of time that the copilot maintained visual focus outside the aircraft was higher than in the previous OH-58F crewstation assessment (table 3), maintaining visual focus outside the aircraft for only 14% of a typical zone reconnaissance mission may be too low to adequately assist the pilot with crew tasks such as obstacle avoidance and terrain flight navigation. The low percentage of time that the copilots were visually focused outside the aircraft was likely due to the workload required to manage information on the crewstation displays, operate the NMS and the lack of in-depth experience that the copilots had with the crewstation interface. It will be important to assess visual gaze during future human factors engineering (HFE) crewstation evaluations to determine if the copilot workload precludes maintaining adequate visual focus outside the aircraft.
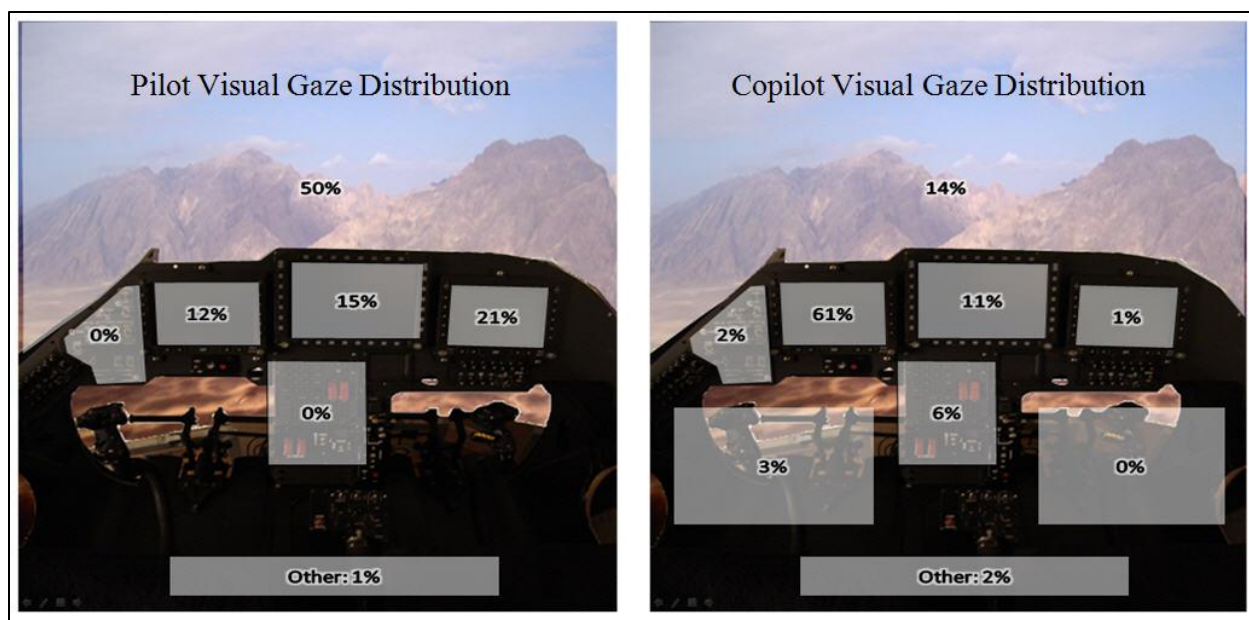
Figure 5. Pilot and copilot visual gaze and dwell times.

Table 3. Comparison of eye tracker results for OH-58F, AH-64D, and ARH simulations.

	AH-64D/UAS Workload Assessment (Block III)		AH-64D Workload Assessment (Block III)		ARH HFE-CAAS Evaluation		OH-58F HFE #1 Evaluation		OH-58F HFE #2 Evaluation	
	Flying Pilot	Non Flying Pilot	Flying Pilot	Non Flying Pilot	Flying Pilot	CPG	Flying Pilot	Non Flying Pilot	Flying Pilot	Non Flying Pilot
Outside	75%	4%	75%	6%	75%	3%	61%	7%	50%	14%
Inside	25%	96%	25%	94%	25%	97%	39%	93%	50%	86%

The pilots typically spent 50% of the time visually focused OTW during VFR missions. The amount of time (50%) that the pilots were visually focused inside the aircraft was due to instrument scans, lack of in-depth experience with the crewstation interface, and the "helping behaviors" of the pilots when flying the aircraft. The pilot occasionally helped the copilot manage information on the crewstation displays, which kept both of them visually focused inside the crewstation.

Comparison of Eye Tracker Data

Table 3 shows a comparison of OH-58F, AH-64D, and Armed Reconnaissance Helicopter (ARH) eye tracker data for VFR flight during simulations. While the simulator, missions, and personnel experience levels were different for each simulation evaluation, it is interesting to note

the differences in visual gaze and dwell times for each evaluation. Past discussions with several AH-64D and OH-58D pilots identified that:

1. The flying pilot should typically maintain visual gaze and dwell times outside the aircraft for 70–80% of the time during VFR flight.

2. The non-flying pilot should maintain visual gaze and dwell times outside the aircraft for 30–40% of the time during VFR flight.

3.2   Crew SA

3.2.1   Pilot SA Ratings

The pilots and copilots reported that they typically experienced adequate to good SA during missions; they were able to maintain knowledge of the aircraft energy state, tactical environment, and mission; were able to partially anticipate and accommodate trends; and had minimal task shedding (due to high-workload) during the missions. The pilots and copilots typically reported "fairly high" levels of SA of the location of their ownship, route information (e.g., phase lines), friendly units, and status of the aircraft systems (e.g., fuel consumption). They reported "fairly high" to "borderline" SA of the location of enemy units and location of cultural features (e.g., bridges).

3.2.2   SME SA Ratings

The SMEs provided an independent assessment of SA based on the scale shown in table 4. The mean SME SA rating was 2.54. This indicates that the SMEs reported that the crews typically had adequate levels of SA with some variation between aircrew perception of entities on the battlefield and reality. The SMEs commented that crew fixation on the NMS imagery presented on the MFD and using too narrow of a zoom on the NMS reduced overall pilot SA during four missions.

Table 4. SME SA rating.

SME SA Ratings	
1	Crew was consistently aware of all entities on the battlefield.
2	Crew was aware of the battlefield with minor or insignificant variation between perception and reality.
3	Crew was aware of the battlefield. Variation between reality and perception did not significantly impact mission success.
4	SA needs improvement. Lack of SA had some negative effect on the success of the mission.
5	Lack of SA caused mission failure.

Mean Rating
2.54
(SD = 1.13)

3.3 SME Mission Success Ratings

At the end of each mission, SMEs rated whether the mission was a success or failure. The criteria used by the SME to rate mission success or failure was whether the aircrew completed the mission requirements and did not get shot down or crash. The SMEs rated all of the missions (100%) as "successful" and "objectives completed" (figure 6).

Figure 6. SME ratings of mission success.

3.4 PCI

The pilots were mostly favorable in their ratings of the crewstation interface (appendix C). They reported they were able to effectively use the MFD pages and functions; quickly navigate through the pages, sub-pages, and overlays on the crewstation displays; easily use the switches on the cyclic and collective and easily use the switches to control the NMS. They also reported that it was easy to detect the Warnings, Cautions, and Advisories on the MFD and entry into operational limits. Three pilots commented that the colors used for the symbology (e.g., magenta) on the MFDs made it difficult for them to quickly and easily distinguish the symbology. The pilots reported that the Control Display Subsystem (CDS) 5 software was somewhat quicker and easier to use than the CDS 4 software. They also reported that the 6×8 display enhanced SA and that NMS functionality is an improvement over the Mast Mounted Sight (MMS) on the OH-58D Kiowa Warrior. Several minor crewstation improvements that should be made to the OH-58F were reported by the pilots (appendix D).

3.5 Simulator Sickness

3.5.1 OH-58F Simulator

The pilots and copilots reported that they typically experienced very mild to mild simulator sickness symptoms during the evaluation. The overall mean Total Severity (TS) score (post mission) for the pilots and copilots was 19.23 (table 5). The mean TS score for the pilot was 18.17 and the mean TS score for the copilot was 20.30. When flying the aircraft, the pilots were

visually immersed in the changing scene outside the aircraft and often transitioned their visual gaze inside the aircraft to monitor information displayed on the MFDs. The copilots primarily maintained their visual gaze inside the aircraft to monitor and input data into their MFDs. One pilot commented that visual after-effects increased about 30 min after the end of the missions that he performed; all pilots commented that the simulator sickness symptoms were typically mild. Overall, the simulator did not appear to induce debilitating simulator sickness symptoms and should continue to be a suitable simulation environment for future assessments.

Table 5. SSQ ratings.

Condition	Nausea Subscale	Oculomotor Subscale	Disorientation Subscale	TS Score (Mean)
Pre-Mission Pilot	10.90	17.33	0	12.82
Pre-Mission Copilot	2.73	11.91	1.99	7.48
Post Mission Pilot	10.90	19.90	13.92	18.17
Post Mission Copilot	6.81	22.74	23.86	20.30
Post Mission Combined (Pilot and Copilot)	8.86	21.32	18.91	19.23

3.5.2 Comparison of OH-58F Simulator SSQ Scores to Other Helicopter Simulators

To assess whether the SSQ ratings provided by the pilots during the HFE assessment were similar or different to ratings obtained in other helicopter simulators, the mean SSQ scores for the OH-58F simulator were compared to the mean SSQ scores for several other helicopter simulators (table 6). The other helicopter simulators were the AH-64D, S-3H, and CH-46E, CH 53D, CH-53F, Sikorsky RAH-66 Engineering Development Simulator (EDS), RAH-66 Comanche Portable Cockpit (CPC), Armed Reconnaissance Helicopter (ARH), and the simulator used during the UH-60M from the Early User Demo (EUD) and Limited Early User Evaluation (LEUE). These simulators typically induced very mild to mild simulator sickness symptoms in pilots.

Table 6. Comparison of OH-58F simulator SSQ ratings with other helicopter simulators.

Simulator	Nausea Subscale	Oculomotor Subscale	Disorientation Subscale	Total Severity Score (Mean)
ARH Simulator	18.02	21.48	9.28	20.15
OH-58F Simulation #2	**8.86**	**21.32**	**18.91**	**19.23**
SH-3H	14.70	20.00	12.40	18.80
OH-58F Simulation #1	16.43	12.21	10.05	15.16
RAH-66 EDS	11.84	14.98	4.54	13.25
CH-53F	7.50	10.50	7.40	10.00
RAH-66 CPC	3.29	12.94	7.89	9.80
UH-60M (LEUE)	6.36	11.81	3.09	9.15
AH-64D – IUAS (RACRS)	9.01	7.58	4.64	8.51
UH-60M (EUD)	13.88	6.89	0	8.50
CH-53D	7.20	7.20	4.00	7.50
CH-46E	5.40	7.80	4.50	7.00
AH-64D VUIT-2 (RACRS)	3.18	5.05	4.64	4.98

3.6   Audio Alerting

The overall design of the audio alerting system received good to high ratings from the pilots for alert presentation logic, the utility of the audio alerting system functions and characteristics, the audio workload associated with using the system, and pilots' reported air vehicle and tactical SA achieved during the simulated missions. Two design features received moderate utility ratings. There were no differences in the pilots' ratings of the two text-to-speech voices for distinctiveness. The Version A voice was initially rated as more intelligible than the Version B voice, but this difference diminished then disappeared as the pilots progressed from hearing the audio alerts in isolation to hearing them during practical cockpit exercises to hearing them in mission context. The pilots' ratings and their comments did indicate a strong preference for the current audio alerting tones implemented in the OH-58D aircraft and a bias against any mechanical sounding voice, due to negative associations with the APR-39A radar warning system in their current aircraft. Based on the results discussed in the audio alerting assessment, PLRA made the following recommendation.

The current Version A voice alerts that are loaded in the DICS should be replaced with one of the following:

- A new set of alerts spoken in a more natural sounding but still highly distinctive and highly intelligible female voice

- A new set of alerts spoken in the Version A voice with more consistent voice qualities and speaking rates across all the alerts

- The Version A alerts as tested in HFE#2 with some changes

3.7   Crewstation Design Enhancements

Several design enhancements to the OH-58F crewstation displays have been made via the Crewstation Working Group and simulation process (see figure 7). These enhancements improved the functionality and presentation of display pages to pilots and overall crewstation interface. Examples of the enhancements are improved color-coding of battlefield graphics, reduced number of button presses to display information on MFDs, refinement of the composite map page, and enhanced presentation of operational limits on the Systems Page. Additionally, the Crewstation Working Group and simulation process has aided in the refinement of TTP for OH-58F operational employment.
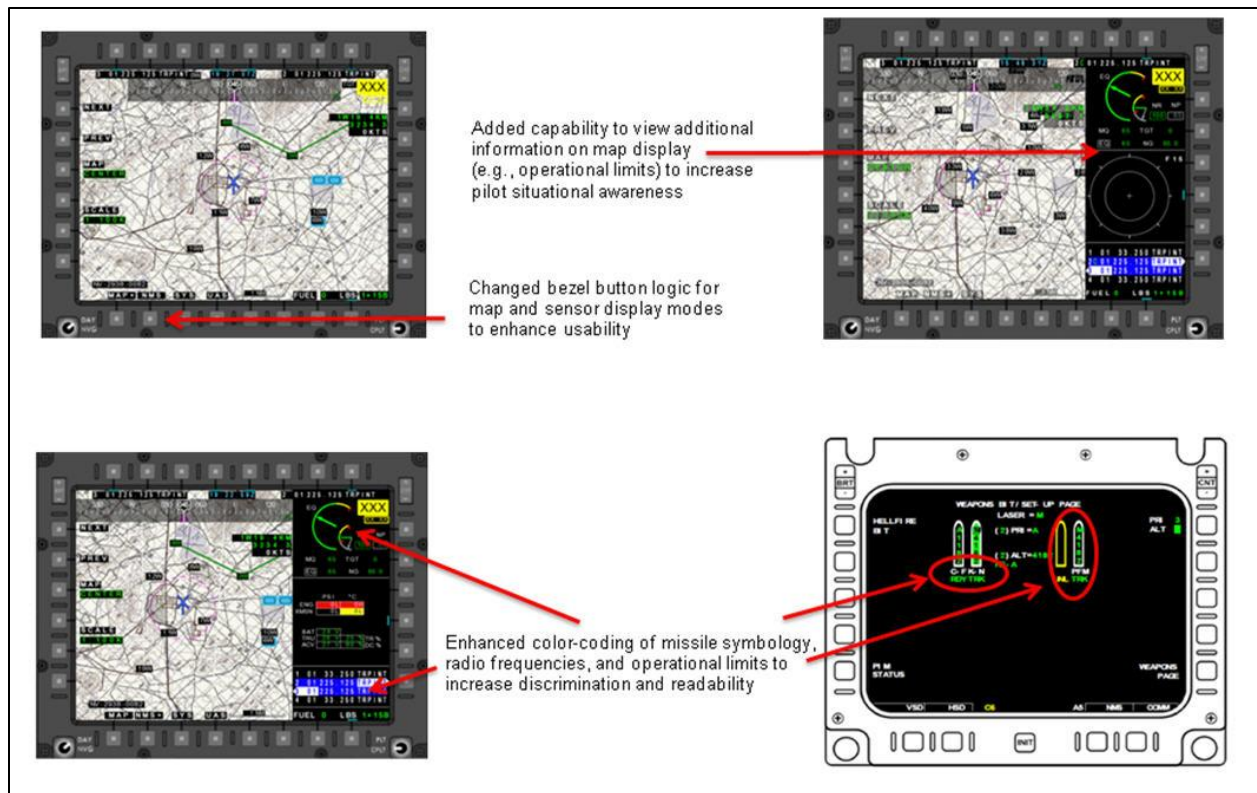
Figure 7. Examples of crewstation design enhancements.

4. Summary

4.1   Crew Workload

The pilots and copilots reported that workload was manageable for the flight and mission tasks they performed during the missions and the SMEs also reported that workload was manageable for the pilots and copilots. The average mission workload ratings provided by the pilots, copilots, and SMEs were lower than the Objective (5.0) and Threshold (6.0) BWRS workload rating requirements contained in the OH-58F CDD.

4.2   Visual Workload

The copilots spent 14% of the time visually focused OTW during VFR missions. The small percentage of time that the copilots were visually focused outside the aircraft was likely due to the workload required to manage information on the crewstation displays, operate the NMS, and the lack of in-depth experience that the copilots had with the crewstation interface. The pilots typically spent 50% of the time visually focused OTW during VFR missions. The amount of time (50%) that the pilots were visually focused inside the aircraft was due to instrument scans, lack of in-depth experience with the crewstation interface, and the "helping behaviors" of the

pilots when flying the aircraft. The pilot occasionally helped the copilot manage information on the crewstation displays, which kept both of them visually focused inside the crewstation.

4.3   Crew SA

The pilots and copilots reported that they typically experienced adequate to good SA during missions, were able to maintain knowledge of the aircraft energy state, tactical environment and mission; were able to partially anticipate and accommodate trends; and had minimal task shedding (due to high-workload) during the missions. They reported that they had adequate SA of most battlefield elements (e.g., location of their ownship, route information) during the missions. The SMEs reported that the crews typically had adequate levels of SA during missions.

4.4   Pilot-Crewstation Interface

The pilots reported they were able to effectively use the MFD pages and functions; quickly navigate through the pages, sub-pages, and overlays on the crewstation displays; easily use the switches on the cyclic and collective; and easily use the switches to control the NMS. They also reported that it was easy to detect the Warnings, Cautions, and Advisories on the MFD and entry into operational limits. Three pilots commented that the colors used for the symbology (e.g., magenta) on the MFDs made it difficult for them to quickly and easily distinguish the symbology. The pilots reported that the CDS 5 software was somewhat quicker and easier to use than the CDS 4 software. They also reported that the 6×8 display enhanced SA and the NMS functionality is an improvement over the MMS on the OH-58D Kiowa Warrior.

4.5   Mission Success

All of the missions performed by the aircrews were rated as "successful" by the SMEs who observed each mission.

4.6   Simulator Sickness

The pilots and copilots reported that they typically experienced very mild to mild simulator sickness symptoms during the evaluation. The OH-58F simulator did not induce debilitating simulator sickness symptoms and should continue to be a suitable simulation environment for future assessments.

4.7   Audio Alerting

The overall design of the audio alerting system received good to high-ratings from the pilots for alert presentation logic, the utility of the audio alerting system functions and characteristics, the audio workload associated with using the system, and pilots' reported air vehicle and tactical SA achieved during the simulated missions.

4.8   Simulator Functionality

Simulator functionality was somewhat limited during the HFE #2 assessment. The information and data listed in the Results and Summary sections of this report should be interpreted based on these limitations. Future simulations should include full functionality of the simulated subsystems and crewstation interface.

5.   Recommendations

The following recommendations are made to enhance the overall effectiveness and suitability of the OH-58F crewstation development and assessment process:

- Continue to upgrade the OH-58F simulator to make it as representative of the production design as possible.

- Continue to maximize the amount of OH-58F crewstation experience for pilots prior to future assessments.

- Workload, SA, crewstation interface and simulator sickness (as applicable) data should be collected during future OH-58F crewstation assessments, developmental testing, and operational testing. This continuity will allow direct comparison (after further development and integration of the OH-58F crewstation) to assess workload, SA, and the crewstation interface.

- Address and resolve the PCI issues identified during the HFE simulation assessment.

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Appendix A. Bedford Workload Rating Scale Scores and Pilot Comments

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This appendix is presented in its original form without editorial change.

BEDFORD WORKLOAD RATING SCALE (BWRS)

Workload Description	"Rating"
Workload insignificant	1
Workload low	2
Enough spare capacity for all desirable additional tasks	3

Workload Description	"Rating"
Insufficient spare capacity for easy attention to additional tasks	4
Reduced spare capacity. Additional tasks cannot be given the desired amount of attention	5
Little spare capacity: level of effort allows little attention to additional tasks	6

Workload Description	"Rating"
Very little spare capacity, but maintenance of effort in the primary tasks not in question	7
Very high workload with almost no spare capacity. Difficulty in maintaining level of effort	8
Extremely high workload. No spare capacity. Serious doubts as to ability to maintain level of effort	9

Workload Description	"Rating"
Task abandoned. Pilot unable to apply sufficient effort	10

YES — Was workload satisfactory without reduction in spare (workload) capacity? — NO

YES — Was workload tolerable for the task? — NO

YES — Was it possible to complete the task? — NO

Pilot Decisions

BEDFORD WORKLOAD RATING SCORES

Task No.	Flight and Mission Tasks	Pilot Workload Rating	Copilot Workload Rating
1026	Maintain Airspace Surveillance	2.29	3.20
1028	Perform Hover Power Check	3.67	---
1030	Perform Hover Out-Of-Ground-Effect (OGE) Check	3.00	---
1032	Perform Radio Communication Procedures	2.50	2.50
1038	Perform Hovering Flight	3.71	---
1040	Perform Visual Meteorological Conditions (VMC) Takeoff	2.50	2.00
1044	Navigate by Pilotage and Dead Reckoning	2.29	2.50
1046	Perform Electronically Aided Navigation	2.25	2.86
1048	Perform Fuel Management Procedures	2.33	1.83
1052	Perform VMC Flight Maneuvers	2.38	2.00
1058	Perform VMC Approach	2.80	2.00
1066	Perform A Running Landing	---	2.00
1070	Respond to Emergencies	3.12	2.00
1074	Respond to Engine Failure in Cruise Flight	3.67	3.00
1140	Perform Nose Mounted Sensor (NMS) Operations	---	3.86
1142	Perform Digital Communications	3.00	2.29
1155	Negotiate Wire Obstacles	2.00	2.00
1170	Perform Instrument Takeoff	3.80	3.00
1176	Perform Non Precision Approach (GCA)	---	---
1178	Perform Precision Approach (GCA)	---	---
1180	Perform Emergency GPS Recovery Procedure	6.00	---
1082	Perform an Autorotation	5.00	4.00
1182	Perform Unusual Attitude Recovery	6.50	5.00

1188	Operate ASE/transponder	2.00	3.00
1184	Respond to IMC Conditions	5.00	6.00
1194	Perform Refueling / Rearming Operations	2.00	2.00
1404	Perform Electronic Countermeasures / Electronic Counter-Countermeasures	2.50	3.00
1405	Transmit Tactical Reports	2.00	2.71
1407	Perform Terrain Flight Takeoff	2.43	---
1408	Perform Terrain Flight	2.38	---
1409	Perform Terrain Flight Approach	2.67	---
1410	Perform Masking and Unmasking	2.33	---
1411	Perform Terrain Flight Deceleration	2.33	2.50
1413	Perform Actions on Contact	2.62	3.00
1416	Perform Weapons Initialization Procedures	2.33	2.25
1422	Perform Firing Techniques	2.50	3.00
1456	Engage Target with .50 Cal	2.50	---
1458	Engage Target with Hellfire	3.00	2.00
1462	Engage Target with Rockets	2.50	---
1472	Perform Aerial Observation	2.62	2.86
1471	Perform Target Handover	2.00	2.00
1472	Aerial Observation	2.50	2.57
1473	Call for Indirect Fire	---	---
2010	Perform Multi-Aircraft Operations	2.67	2.50
2127	Perform Combat Maneuvering Flight	3.00	4.00
2128	Perform Close Combat Attack	3.00	---
2129	Perform Combat Position Operations	3.00	---
2164	Call for Tactical Air Strike	---	5.00
-----	Zone Reconnaissance	2.60	2.80
-----	Route Reconnaissance	2.62	2.57
-----	Area Reconnaissance	2.57	2.62
-----	Aerial Surveillance	2.50	2.20
-----	Overall Workload for the Mission	2.75	3.38

Pilot Workload Comments:

Comments for flight and mission tasks that were given a workload rating of '5' or higher during missions:

Task (1028) Perform Hover Power Check
- Different fidelity in simulator than aircraft.

Task (1038) Perform Hovering Flight
- Hovering difficult due to simulator and depth perception.
- Different fidelity in simulator than aircraft.

Task (1182) Perform Unusual Attitude Recovery
- Focus is on recovering aircraft so everything else is mute.

Task (1184) Respond to IMC Conditions
- Aircraft is the focus so other tasks are dropped.

Task (1140) Perform Nose Mounted Sensor (NMS) Operations
- Attention focused inside for almost the duration. NMS ops took up so much time that ASE, airstrike, reports, etc. quality suffered.

Task (1170) Perform Instrument Takeoff
- Higher workload trying to control aircraft IIMC. Partly due to the nature of the task, compounded by lack of "seat of the pants" feel and control input lag time of simulator.

Task (1180) Perform Emergency GPS Recovery Procedure
- Higher workload trying to control aircraft IIMC. Partly due to the nature of the task, compounded by lack of "seat of the pants" feel and control input lag time of simulator.
- Simulator flight controls are not as responsive as the real aircraft. I feel like I was constantly over correcting for inputs.

Task (1074) Respond to Engine Failure in Cruise Flight
- Didn't have audio indicators of engine failure

Task (1082) Perform an Autorotation
- Engine Out at 140ft with 50deg left bank.
- Didn't have audio indicators of engine failure
- Different fidelity in simulator than aircraft.

Miscellaneous Workload Comments:
- IMC/Unusual Attitude/Airspace Surveillance/NMC/Overall Workload – very busy cockpit makes things difficult to find.
- Operating the NMS required additional attention due to the newness of it and trying to adjust it with switches that do not work (simulator issue).

SME Workload Comments:

- Mission #8 - Workload during engagements and operations vicinity of the objective high enough to cause left seat pilot to momentarily lose SA causing disorientation/association of ASE indications, miss some ASE indications completely and also some radio calls.

- Mission #8 - When in contact, left seat pilot lost SA and missed some ASE indications as well as some radio calls.

- Mission #4 - Left seat pilot had RFD issues as well as SA while attempting NMS operations to ID targets. RFD issues were failing to ID what radio he was talking on.

- Mission #2 - Workload was increased due to some fixation from NMS simulation.

- Mission #3 - Right seat pilot transferred controls during IIMC recovery ops.

Appendix B. Situation Awareness Ratings and Comments

This appendix is presented in its original form without editorial change.

China Lake Situational Awareness Rating Scale (CLSA)

VERY GOOD 1	• Full knowledge of aircraft energy state, tactical environment and mission • Full ability to anticipate and accommodate trends
GOOD 2	• Full knowledge of aircraft energy state, tactical environment and mission • Partial ability to anticipate and accommodate trends • No task shedding
ADEQUATE 3	• Full knowledge of aircraft energy state, tactical environment and mission • Saturated ability to anticipate and accommodate trends • Some shedding of minor tasks
POOR 4	• Fair knowledge of aircraft energy state, tactical environment and mission • Saturated ability to anticipate and accommodate trends • Shedding of all minor tasks as well as many not essential to flight safety and mission effectiveness
VERY POOR 5	• Minimal knowledge of aircraft energy state, tactical environment and mission • Oversaturated ability to anticipate and accommodate trends • Shedding of all tasks not absolutely essential to flight safety and mission effectiveness

Copilot Mean Rating 2.75 (SD = .886)

Pilot Mean Rating 2.50 (SD = .535)

Battlefield Elements	Very High-Level of Situation Awareness		Fairly High-Level of Situation Awareness		Borderline		Fairly Low Level of Situation Awareness		Very Low Level of Situation Awareness	
	Right Seat	**Left Seat**	**Right Seat**	**Left Seat**	**Right Seat**	**Left Seat**	**Right Seat**	**Left Seat**	**Right Seat**	**Left Seat**
Location of Enemy Units	0 %	0 %	63 %	37 %	37 %	63 %	0 %	0 %	0 %	0 %
Location of Friendly Units	0 %	0 %	88 %	75 %	13 %	13 %	0 %	13 %	0 %	0 %
Location of My Aircraft During Missions	13 %	13 %	50 %	50 %	25 %	0 %	13 %	38 %	0 %	0 %
Location of Cultural Features (e.g., bridges)	0 %	0 %	50 %	40 %	50 %	40 %	0 %	20 %	0 %	0 %
Route Information (ACPs, BPs, EAs, RPs, etc.)	0 %	0 %	88 %	75 %	13 %	13 %	0 %	13 %	0 %	0 %
Status of My Aircraft Systems (e.g., fuel consumption)	0 %	0 %	75 %	71 %	25 %	14 %	0 %	14 %	0 %	0 %

Pilot Situational Awareness Comments

SA1: If you rated 'Poor' or 'Very Poor' - explain.

- Would have been 'Good' for 'Very Good' except for initial trouble with associating target position in relationship to town when using NMS orientation, etc.
- Difficult to determine place on the ground in relation to objective, friendlies, enemy, LZ, PZ/Cardinal Direction.

SA2: If you rated a battlefield element 'Fairly Low' or 'Very Low' – explain.

- At times I went through boundaries. I think it was due to phase line colors (hard to see on display) and map background. (Lack of experience).
- Location of aircraft during mission due to lack of experience with NMS – unfamiliar with NMS switches.
- Map color on 5x7 and 6x9 in addition to character colors made things difficult to find on the screen. Colors were a little too much to process.
- Fuel consumption/ACFT Systems were difficult to find.

- My attention while in the left seat is focused so intently inside that it was extremely difficult to come back outside and figure out where or which way was North.

Miscellaneous comments:
- Simulator display issue location of enemy units – 'Good' in town, 'Fair' with personnel in open.

SME Situation Awareness Comments:

- Mission #6 - Crew maintained very good SA throughout entire mission.
- Mission #8 - Crew did not exploit NMS capabilities. Consistently positioned aircraft too close to objective, leading to multiple enemy engagements. When all crew Hellfire expended, crew elected to engage T-72s, ZSU-23-4, and BMP with .50 cal instead of engagements with CAS, artillery, or ground forces.
- Mission #8 - Crews were focused on OBJ Hawk and did not realize additional enemy targets around outside perimeter of OBJ Hawk. Poor crew decision making and lack of proper TTP's had negative effect on success of mission.
- Mission #1 - Crews were given "help" to see truck under wires, which led to a lack of SA, but as mission progressed crew gained SA.
- Mission #2 - Simulation caused some SA issues. Crew also had some NMS fixation during recon of route and area around cordon and search objective.
- Mission #3 - First mission for this crew – SA increased as familiarity increased. By end of mission, crew had good SA.
- Mission #3 - Crew maintained NMS in a zoomed mode and missed some SA due to that for zoomed in. Aircrew also had battlefield graphics color issues which reduced SA and crew flew past a phase line restriction boundary.
- Mission #4 - Took awhile for left seater to get accustomed to NMS symbology.
- Mission #4 - Crew had some SA issues most likely with battlefield graphics which caused them to move across PL New Mexico restriction. Also had SA issues while attempting to ID PAX at NAI 2. Sim restricts actual visual recognition of obvious sightings.
- Mission #5 - None. Excellent use of all assets (JVMG, BFT, NMS).
- Mission #5 - Crew started to increase workload which caused reduction in SA and caused boundary restriction violations a couple of times.

Appendix C. Pilot-Crewstation Interface (PCI) Ratings and Comments

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This appendix is presented in its original form without editorial change.

PV1. The following table lists the components (e.g., display pages, sub-pages, overlays) of the KW CASUP crewstation. For each component, indicate whether or not you experienced a problem using the component in a quick and efficient manner during the missions. Check 'Yes' if you experienced one or more problems. Check 'No' if you did not experience any problems. Check 'Not Used' if you did not use the component during the simulation.

- Multifunction Displays (MFD)

    - Vertical Situation Display   Yes **0%**   No **100%**

    - Horizontal Situation Display   Yes **0%**   No **100%**

    - NMS Operations   Yes **0%**   No **100%**

    - COM Pages   Yes **0%**   No **100%**

    - NAV Pages   Yes **0%**   No **100%**

    - Digital Map   Yes **0%**   No **100%**

    - Engine Instruments   Yes **25%**   No **75%**

    - ASE Pages   Yes **0%**   No **100%**

    - Weapons Pages   Yes **0%**   No **100%**

    - Managing GPS/Flight Plan   Yes **0%**   No **100%**

    - Mission Page   Yes **0%**   No **75%**   Not Used **25%**

    - Warning, Caution, Advisory Disp. Yes **0%**   No **100%**

    - 'Direct To'   Yes **0%**   No **100%**

    - ACP Function   Yes **0%**   No **100%**

    - Fuel Management Pages   Yes **25%**   No **75%**

    - Data Function   Yes **0%**   No **100%**

    - ACP Function   Yes **0%**   No **100%**

    - Autopaging   Yes **0%**   No **100%**

If you answered "Yes" to any of the questions, describe a) the problems you experienced, b) how much the problems degraded your performance, and c) any recommendations you have for improving the design of the components.

Pilot comments:

- All the systems were very easy to use. This is a good improvement over current software. I was slower at tasks in the simulator, but that was due to the newness of the system.
- Engine instruments are hard to find. Especially during emergencies.
- Fuel management page timer should be working to accurately reflect realism. It would create an extra advisory for pilots to respond to. (Sim issue).

PV2. How quickly were you able to navigate through the pages, sub-pages and/or overlays for:

Vertical Situation Display   (Circle one)

1	Avg. Rating 1.75	2	3	4	5
Very Quickly		Somewhat Quickly	Borderline	Somewhat Slowly	Very Slowly

Horizontal Situation Display (Circle one)

1	Avg. Rating 2	3	4	5
Very Quickly	Somewhat Quickly	Borderline	Somewhat Slowly	Very Slowly

Digital Map   (Circle one)

1	Avg. Rating 2	3	4	5
Very Quickly	Somewhat Quickly	Borderline	Somewhat Slowly	Very Slowly

Engine Instruments   (Circle one)

1	2	Avg. Rating 2.25	3	4	5
Very Quickly	Somewhat Quickly		Borderline	Somewhat Slowly	Very Slowly

If you answered 'Somewhat Slowly', or 'Very Slowly' to any of the questions, list the component and why navigation was slow (e.g., 'navigating the menu system on the digital map was a slow process due to having to page through several screen displays').

Pilot comments:

- No comments.

PV3. Please answer the following questions regarding the Nose Mounted Sensor (NMS).

PV3-1. Did you experience any problems using the following NMS switches/controls?

o Sensor Select	Yes **0%**	No **100%**
o FOV Select	Yes **0%**	No **100%**
o Laser	Yes **0%**	No **100%**
o LOS Designate	Yes **0%**	No **100%**
o Range/Polarity	Yes **0%**	No **100%**
o Manual Slave	Yes **25%**	No **75%**
o Point Track	Yes **0%**	No **100%**

If you answered "Yes" to any of the questions, describe a) the problems you experienced, b) how much the problems degraded your performance, and c) any recommendations you have for improving the design of the NMS switches/controls.

Pilot comments:

- NMS doesn't move in forward mode. Can it move as it does now?

PV4. Did you have difficulty using any of the switches on the collective or cyclic grips?

Collective Grip	Yes **0%**	No **100%**
Cyclic Grip	Yes **0%**	No **100%**

If you answered "Yes" for either flight control, please list which flight control and switch(es), and the problems you experienced (e.g., confused two switches due to similar shape, switch was too hard to reach).

Pilot comments:

- No comments

PV5. Was there any symbology depicted on the following displays/pages that was difficult to quickly and easily understand, cluttered, or otherwise difficult to use?

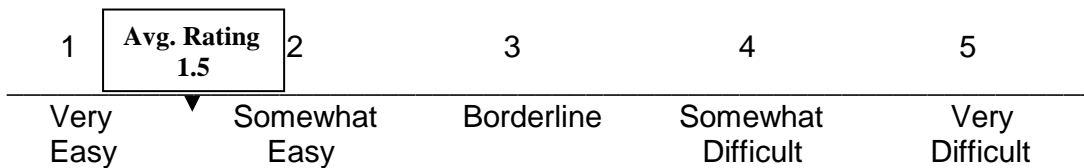|		
Vertical Situation Display	Yes **0%**	No **100%**
Horizontal Situation Display	Yes **25%**	No **75%**
ESIS	Yes **50%**	No **50%**
Engine Instruments	Yes **25%**	No **75%**
Digital Map	Yes **50%**	No **50%**
ASE	Yes **25%**	No **75%**
NMS Pages	Yes **25%**	No **75%**

If you answered "Yes" to any of the questions, please describe a) the display/page, b) the symbology that was difficult to understand, c) how the symbology degraded your performance, and d) any recommendations you have for improving the design of the display page and/or symbology.

Pilot comments:

- ESIS is too small. Engine instruments are too new for me to interpret.
- ESIS: The low position of this instrument makes it hard to read.
- HSD/MAP pages are extremely cluttered. NMS features make navigation through the system difficult.
- Digital Map: Magenta for NMS is difficult to see.
- ASE: Blue tracking is difficult on black background.

PV6. How easy was it to detect the following indication on the displays?

Warning/Caution/Advisory (MFD)

1	Avg. Rating 1.5	2	3	4	5
Very Easy		Somewhat Easy	Borderline	Somewhat Difficult	Very Difficult

Entry into Operational Limits

1	Avg. Rating 1.5	2	3	4	5
Very Easy		Somewhat Easy	Borderline	Somewhat Difficult	Very Difficult
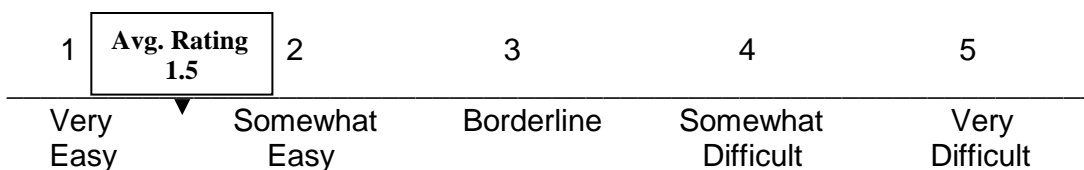
Low Fuel

Avg. Rating 1 ▼	2	3	4	5
Very Easy	Somewhat Easy	Borderline	Somewhat Difficult	Very Difficult

If you answered "Somewhat Difficult", or "Very Difficult", list which indication you had difficulty detecting/understanding, why you had difficulty, and any recommendations to make the indication more easily detectable and/or understandable.

Pilot comments:

- No comments.

PV7. Did you have any problems using the overhead panels due to location, inaccurate labeling, etc?

Yes **0%**   No **50%**   NU **50%**

PV8. Did you have any problems using the following switches and controls on the instrument panel?

CMWS Manual Dispense Switch	Yes **0%**	No **75%**	NU **25%**
SCAS Control Panel	Yes **0%**	No **50%**	NU **50%**
FADEC Switch	Yes **0%**	No **25%**	NU **75%**
MFK	Yes **0%**	No **100%**	
Armament Control Panel	Yes **0%**	No **100%**	
Channel Select Switch	Yes **0%**	No **100%**	

If yes, list the switches and/or controls and describe the problem(s)

Pilot comments:

- No comments.

PV9a. Did you have any problems viewing information (symbology, text, etc) on the following displays:

6x8 Display   Yes **50%**   No **50%**

5x7 Display	Yes **25%**	No **75%**
ESIS Display	Yes **50%**	No **50%**

If yes, list the information you had problems viewing:

Pilot comments:

- Color MFDs can make things difficult to find.
- NMS magenta difficult to see.
- ESIS: Hard to read with low mounting position.

PV9b. Did you have any problems using the bezels, knobs or hot keys on the 6x8 display?

Yes **0%**   No **100%**

PV10. Did the LPCAP (digital ICS) restrict cyclic movement in the right seat?

Yes **0%**   No **100%**

If yes, describe the how much the LPCAP restricted movement and in which axis:

No comments:

PV11. Rate whether the CDS5 software was much more or less effective (quicker and easier to use) than the CDS4 software you have used on the KW.

1	Avg. Rating 2	3	4	5
Much More Effective	Somewhat More Effective	About The Same	Somewhat Less Effective	Much Less Effective

If 'Somewhat Less' or 'Much Less Effective', explain why:

Pilot comments:

- No comments.

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Appendix D. Top Crewstation Improvements

This appendix is presented in its original form without editorial change.

OH-58F Functionality That Is An Improvement vs. OH-58D Kiowa Warrior

Nose Mounted Sensor

- NMS optics and functions is an improvement over current aircraft
- NMS is outstanding.
  NMS is great for increased stand-off

Displays

- The 6x8 is great and allows for additional situational awareness for the pilot on the controls
- 6x8 MFD is an improvement (improves situational awareness)
- Systems are organized well on the 6x8 and using PWR is nice to have versus TGT or highest value indicated.
- Color MFDs are an improvement
- RFD is much more useful.
- Auto paging is an improvement
- Engine/aircraft performance displays are an improvement

Improvements that need to be made to OH-58F crewstation:

- Digital map (magenta) is difficult to read
- ASE blue tracking on black background is difficult to see – needs improvement.
- Declutter options – option to remove bezel labels but remain functional.
- Add a compass rose to the 6x8.
- Make the ESIS easier to read.
- Consider relocating fuel quantity location
- Need a NMS desktop trainer.
- Expanded checklist for NMS operations.
- Label power display with the power monitored.
- A negative would be that the left seater will spend more time inside the aircraft (due to improved NMS).
- Need a hologram sight for weapons on dash.
- Need tones with all WCA's.
- TGT list hotkey from NMS page.

List of Symbols, Abbreviations, and Acronyms

AAR   after action review

AOI   area(s) of interest

APEX   Advanced Prototype Engineering and Experimentation

ARH   Armed Reconnaissance Helicopter

ARH   Armed Reconnaissance Helicopter

ARL   U.S. Army Research Laboratory

ASL   Applied Science Laboratories

ATM   Aircrew Training Manual

BHIVE   Battlefield Highly Immersive Visual Environment

BIT   Built-In Test

BWRS   Bedford Workload Rating Scale

CDD   Capability Development Document

CDS   Control Display Subsystem

CIB   Controlled Image Base

CLSA   China Lake Situational Awareness

CPC   Comanche Portable Cockpit

DAMA   Demand Assigned Multiple Access

DIS   Distributed Interactive Simulation

DREN   Defense Research and Engineering Network

EDS   Engineering Development Simulator

EUD   Early User Demo

GPS   Global Positioning System

HFE   human factors engineering

HLA   High-Level Architecture

HOG	Hands-On Grip
HRED	Human Research and Engineering Directorate
HUMS	Health Usage Monitoring System
IMC	instrument meteorological conditions
JVMF	Joint Variable Message Format
KW CASUP	Kiowa Warrior Cockpit and Sensor Upgrade Program
LEUE	Limited Early User Evaluation
LOBL	lock-on-before-launch
MFD	multifunction display
MMS	Mast Mounted Site
NDI	Northern Digital Incorporated
NMS	Nose Mounted Sensor
OneSAF	One Semi-Automated Forces
OTW	out-the-window
PCI	Pilot-Crewstation Interface
PIM	Pulse Interval Module
PLRA	Psycho-Linguistic Research Associates
SA	situational awareness
SME	subject matter expert
SSDD	Systems Simulation and Development Directorate
SSQ	Simulator Sickness Questionnaire
TCM RA	TRADOC Capability Manager, Reconnaissance Attack
TRADOC	Training and Doctrine Command
TS	Total Severity
TTP	tactics, techniques, and procedures
VFR	visual flight rules

VMC   visual meteorological conditions

VTR   Video Tape Recorder

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